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SEMI-ANNUAL TECHNICAL REPORT

1 June - 30 November 1968

GRAPHICAL MAN/MACHINE COMMUNICATIONS

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Part I. Summary of Research Activities.

A. The Use of Graphics in the Solution of Partial Differential Equations. Harvey Greenfield, Coprincipal Investigator.

1. Advances were made in the attempt to form a composite radiation diffusion and hydrodynamics program between the University of Utah and Los Alamos computer installations. The plan employs an interactive graphical environment. Visits were made several times by Los Alamos computer personnel to further implement and monitor the various program sections that are presently being experimented with in proving good program flow. Certain sections of the program are currently being amplified.

2. The study concerned with examining in detail any general second order system or autonomous third order systems of non-linear differential equations is continuing. There is, at present, also an attempt to examine higher order systems. This study has its application in nuclear reactor dynamics. Inherent is the desirability to change parametric values within feedback functions and observe corresponding changes within the functions, as aids to solving the differential equations of consequence. Since the non-linear system does not have a known analytic solution, a qualitative solution such as a phase plane is being constructed in an interactive fashion. Towards resolving a qualitative solution the following have been achieved:

   a. A phase plane portrait can be constructed for any second order autonomous system and a phase space for any general first or second order or autonomous third order system.
   b. The Rand tablet has been incorporated as an alternative input device to the teletype for constructing

the phase plane.

c. It is possible to determine coordinates of any singular point. Too, various functions in the equations may be displayed. The solution may be displayed as a function of the independent variable and the size of the interest region for this displayed solution, as well as for the phase plane portrait or phase space, can be changed.
d. A display may be changed while retaining any part of it. Drafted output copies may be obtained and their sizes changed interactively.
e. Linearized and non-linear system solutions may be compared.

Also within the realm of nuclear reactor dynamics there is a desire to develop a fast and efficient program for the analysis of neutron flux behavior in space and time in systems with control. Employment of the code should utilize the graphic techniques. Control rod motion programs have been developed to simulate the control system of a particular reactor. An isometric display code has been prepared which permits interaction with the teletypewriter for observation of the neutron flux, over a uniform mesh grid, for any particular time or a continuum of time.. Production of Gerber output plots is possible.

3. The cooperative program with the Department of Physiology is continuing, with the overall objective of determining the nature of neural mechanisms responsible for pain. The computer program formed was for an on-line analysis of information transmitted to the central nervous system from the predominant type of transducer-transmittal fiber, sensing changes of mammalian skin. Using the available interactive graphics and mass storage computer, data analyses were completed of concern to a) fibers responding

to mechanical distortion affecting superficial layers of the skin; b) fibers responding to various stimuli of subcutaneous tissue as fat; c) fibers responding to intense heat, mechanical stimuli, and irritant chemicals.

The spike separation concept and the graphic display of derived computer data are currently being employed for data analysis of three other projects concerned with neural discharges.

4. A new LOCATE subroutine, used to locate storage and attributes of variables for employment in interactive Fortran programs was written and implemented. The routine is flexible and fast. It allows the same normalized variable found in interacting programs to appear in multiple subroutines and it discriminates the particular interactive routine desired.

5. A new research problem has been initiated to develop numerical solutions to the partial differential equations describing the non-isothermal flow of constant-density fluid up to and through a tube entrance with various contractions and expansions. The isothermal flow situation had been reported on and was completed; however, the isothermal solution was limited by instability in certain regions and the requirement of lengthy computer time usage. A technique, the line method, is presently being utilized and shows promise in decreasing computer time requirement. It also appears that it will allow present computer memory storage availability to be adequate for the non-isothermal flow case. After obtaining further verification of the applicability of the line method, an attempt will be made to add the energy equation to the system for formation of the non-isothermal situation.

6. Hemodynamics studies employing computer simulation

techniques are continuing as part of the joint effort with the Division of Artificial Organs. Of particular interest are the problems concerned with blood flow about an atherosclerotic lesion and knowledge of how the lesion subsequently enlarges, and optimizing of blood flow through an artificial heart valve. During this time period an algorithm was written and employed to allow the initiation of graphic display representation of odd shaped obstructions. This allows the change from a simple rectangular obstacle to a more closely defined attempt to model the lesion obstacle or valve leaflet obstacle in the blood flow. Gerber plots were realized for various flow functions of interest to the renal region side arteries, the abdominal aortic bifurcation area and the Starr-Edwards artificial heart valve (all with rigid boundaries and steady flow). Presently, attempts are being made to study the renal region-abdominal aortic bifurcation area as an entity for sites of lesions caused by turbulence factors. Pulsatile flow theory is also being studied.

B. Left Ventricular Dynamics Project. Homer K. Warner, Coprincipal Investigator.

All of the basic hardware items required for the project are believed now to be on hand. These include the input-output interface which will provide communication between the University Univac 1108 (or other) computers and the video recording and playback system which is an integral part of this project. A portable video disc has been acquired which will permit transporting video information from the L.D.S. Hospital Cardiovascular Laboratory to the Merrill Engineering Building for processing. It is evident that both the I/O interface and the portable disc will require further modification or customizing to

adapt them to our particular needs and to assure the performance necessary to accomplish the biological or physiological goals of the project. These modifications are in various stages of completion, some requiring basic design modifications.

Programming efforts are now being directed toward permitting us to use the leased-line facilities between the L.D.S. Hospital and the Merrill Engineering Building to do some data processing using the Control Data Corporation computer at the L.D.S. Hospital.

Some debugging and experimenting is now being done with the acquisition of biological data to confirm the fidelity of the system but these are not actual left ventricular dynamic studies. Consequently, no significant new developments can be reported at this time.

C. Computer Aided Architectural Design System. Stephen L. Macdonald, Coprincipal Investigator.

1. Interactive Graphic Form Manipulation, a series of form and space manipulations, have been described from the architects point of view to be performed on a console consisting of two CRT's, drawing pad and stylus, keyboard, trackball, zoom and scanning mechanism and possibly a few mode buttons. The stylus is intended to be the dominant input manipulative device. It is hoped that the manipulations will permit a designer to generate virtually any three-dimensional form or combination of forms in the memory of the computer. This work is preliminary to perspective plotting and eventually numerically-controlled production of component parts. Programming for the above has been in progress since July and will probably continue for another year. A compiler compiler, named TreeMeta, has been made operational through the help of Dr. Engelbart at Stanford Research Institute.

2. A more detailed constraint and supporting information document has been in progress since October 1 which will deal with more basic information needed for a programmer document approach.

3. Structures. A supporting structures analysis survey and implementation are in various stages of completion as follows:

- 3.1 Linear
  - 3.1a Analysis computer program complete--Frame and Truss
  - 3.1b Geometry--specific type programmed (not general)
  - 3.1c Graphics--programmed; non-manipulative
  - 3.1d Plot and NC not programmed
- 3.2 Plates -- analysis determined; not programmed.
- 3.3 Shells -- general analysis formulas determined; no applications or programming.

4. A general outline of all the supporting general purpose modes, object modes, and attribute modes has been charted for the entire Architectural Design System.

D. Information Processing Systems. David C. Evans, Principal Investigator.

1. In halftone graphics there are no new basic developments to report. Their programs have been improved so that more complex objects can be handled and so that the running time has been shortened. The Fortran V version of the Warnock algorithm is now available. During this period effort has been made to produce some meaningful halftone pictures. Most pictures produced prior to this time were simply test cases for algorithm development. At present colored pictures

representing geophysical information in a region including altitude, magnetic field strength, and gravitational potential are being shot concurrently on a single view. We are much encouraged about the potential for colored halftone perspective pictures being used to represent complex multivariable situations. The high speed halftone producing hardware described in the previous report has not yet been completed but is still in the process.

2. The three-dimensional line drawing display processor and display system developed by Dr. Sutherland at Harvard University has been installed and is now operational, being driven by a PDP-9 computer. During the next period, it is expected to transfer this equipment to a PDP-10 computer which will provide more appropriate memory band-width and processing services for the operation and to activate the head-mounted display system so that full-scale research on the 3-D line drawing display can be pursued.

3. The research facility for non-linear waveform processing under the direction of Dr. Thomas G. Stockham is now being developed. An electro-mechanical picture scanner is being constructed. The quality of our halftone picture producing equipment is being improved. Analog sound recording and reproduction equipment has been installed. High speed precision analog-to-digital and digital-to-analog equipment and high speed precision image scanning equipment is planned and a quiet room for sound experiments is expected to be constructed during the next six months.

Part II. Index of Technical Reports.

A. "FLEX - A Flexible Extendable Language"
Alan C. Kay

The FLEX system consists of merged "hardware" and "software" that is optimized towards handling algorithmic operations in an interactive, man-machine dialog.

The basic form is that of a hardware implementation of a parametric compiler embedded in an environment that is well-suited for semantically describing and pragmatically executing a large class of languages. The semantic language called FLEX includes the compiler-compiler as a string operator and is used as the basic medium for carrying out processes. It is of a higher-level nature and may itself be used for describing many algorithmic processes.

The machine itself is designed to be of the desk-top variety and sell at a low price. Because of these design parameters, many compromises in time and space had to be made to save money. The software system is implemented in read-only memory. To allow any possibility at all of debugging such a scheme, the algorithms involved were distilled down to their essence so that the entire system for the machine can be displayed (in flow diagram form) on a small wall chart.

In many senses the described system is a "syntax-directed" computer.

B. "Syntax Directed On-line Recognition of Cursive Writing"
Yung Taek Kim, David C. Evans

A syntax organization for recognition of handwritten connected-word is studied in this work.

Each writing is cut into strokes at the middle point of every down cave of the writing, and the strokes are named using their directional characteristics and relative

size among the strokes.

A syntax is organized using the hierarchy of the stroke characteristics and self-iteration for the error corrections.

The strokes are classified by the hierarchy and processed to combine the strokes into characters by the hierarchical characteristics.

The lowest level of hierarchy collects those strokes which cannot be combined into characters by their solid stroke characteristics and organizes a two-dimensional family relation for relative combination of the strokes into characters.

The local classifying routines are called for those stroke relations which require the evaluation of the relative characteristics between the strokes for the optimal decision.

C. "A Method for Extending Fortran V for the Interactive Graphical Solution of Numerical Problems"
Alan C. Reed

Interactive computer graphics offers much in the way of bringing the numerical problem solver closer to his algorithm. Techniques may be employed which provide for the execution of the program to be monitored and action taken to help the program find the solution more quickly than is feasible with batch processing. Logic for recovering from breakdowns in the algorithm, much of which would probably not normally be coded into the program, may be economically employed. This paper is the result of a first step toward providing means by which these techniques may be implemented in Fortran programs.

D. "An Interactive Continuous Simulation Language"
Russell L. Hagen

During the recent history of computer science, a new

class of programming languages has evolved. These languages are known as simulation languages. They were developed because of the great need to use simulation as a technique for problem solving and research. Computer simulation has come into increasingly widespread use to study the behavior of systems of which the state of the system changes over time. There have been two main types of simulation languages developed to study these systems, continuous simulation languages to study continuous change models, and discrete simulation languages for the analysis of discrete change models. The models used for analysis with a continuous simulation language are usually represented mathematically by differential or difference equations that describe rates of change of the variables over time. ICSL (Interactive Continuous Simulation Language) falls into this category as a programming language. ICSL not only has the capability for approximating the solutions of continuous change models, but also provides for interaction between man and machine during the course of the simulation. This interaction is in the area of computer graphics.

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13. ABSTRACT

Progress is reported concerning the use of computer controlled graphical displays in the areas of radiation diffusion and hydrodynamics, general second order systems and autonomous third order systems of partial differential equations. Use is made of the phase plane and phase space incorporating a Rand Tablet. A subroutine has been developed to locate storage and attributes of variables in interactive Fortran programs. Studies are continuing on the neural mechanisms responsible for pain; a study of numerical solution of partial differential equations describing non-isothermal flow has been started; computer simulation is being used to study hemodynamics about lesions and artificial valves; equipment has been assembled to study left ventricular dynamics.

Progress is continuing on the use of computer graphics in architecture. Some progress in halftone graphics is reported with no basic developments presented. Colored halftone perspective pictures are being used to represent multivariable situations. Nonlinear waveform processing is being performed on pictures and audio recordings.

Abstracts of technical reports are presented.

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